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February 7, 2008

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Mr. Stephen Landry
NH Department of Environmental Services
6 Hazen Drive, PO Box 95
Concord, NH 03302

RE: RESPONSE TO COMMENTS
PENNICHUCK WATER WORKS WATERSHED RESTORATION PLAN

Dear Mr. Landry:

Attached for your records are five hard copies and one electronic copy of the final *Pennichuck Water Works Pennichuck Brook Watershed Restoration Plan*, incorporating comments received from NH DES via email on December 11, 2007. Some of the responses to comments warranted further explanation beyond the content of the plan, therefore, CEI has prepared a response to each comment below.

Ken Warren Comments

Ken Warren comments that Merrimack River water is nutrient laden and pumped during the summer when potential for stimulating nuisance alga blooms is high. He notes that just after a river pumping episode, there was a serious algae bloom.

Response: Pumping of the Merrimack does occur during summer due to higher demands at that time, and CEI agrees that adding phosphorus at that time may favor algae blooms. However, the total for the summer is still only a portion of the total loading. Further, algal blooms are not instantaneous and are fed by year-round contributions of phosphorus. In particular, several of the ponds have an internal loading of phosphorus that is quite high, hence Pennichuck's choice to aerate the ponds to stop that load is strongly supported. Although this was a phosphorus based model, all of which are by necessity annual, the Restoration program also hits volume issues strongly and these are the efforts that will help reduce dependency on the Merrimack along with separate efforts to clean up the Merrimack itself.

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Paul Piszczek Comments

Page 2-3, Landuse/Landcover: The text states that land uses with greater development have greater runoff. For the most part this is true, but the statement should be qualified with some mention of the effects of steepness.

Response: We agree that slope does play a part in the amount of runoff that occurs. The model uses the average surface slope of each subcatchment in its estimate of runoff. A mention of the effect of surface steepness has been added to the text on page 2-3 under Subwatersheds and under Landuse and Landcover as shown below:

Subwatersheds: "USGS topography was also used to determine the average surface slope of each subcatchment area, which is used in runoff estimations in the model."

Landuse and Landcover: "The type of land use within the watershed has a direct relationship with the amount of runoff and pollutant loadings to the water supply. Land uses with greater levels of impervious area will result in greater runoff than forested areas. The steepness of the land also plays a role in the amount of runoff generated, with steeper areas producing more runoff than flat areas. Generally, the same holds true for pollutant loadings, with greater levels of pollutants associated with more developed areas."

Page 2-3: NRPC land use layer is parcel based. The text implies that the model has good precision (i.e., the model has consistent error), However, a measure of accuracy is not discussed.

Response: The error lies within the designation of land uses. As discussed in the text, the land uses may not accurately represent actual ground land uses, particularly in less densely developed areas where a single house may occupy a large parcel of otherwise forested land. The NRPC land use layer was applied consistently throughout the watershed, knowing that there are some inaccuracies between parcel classifications and actual ground conditions. The modeling results are believed to be relatively accurate on a watershed wide basis, since the streamflows and pollutant loadings are calibrated to reflect actual observed tributary streamflows and in-pond concentrations. There may be some minor inaccuracies in the reported pollutant loadings by land use since actual land uses may differ slightly from NRPC data used in the model, which may shift the balance of loadings between land uses. This is most likely to occur between forest and low density residential land uses, since a large parcel with a

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single house would be classified as low density residential, but may in fact contain a large forested tract of land. These discrepancies are less likely to occur with the more densely developed land uses such as commercial, industrial and high density residential.

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Page 2-5: Precipitation data from Nashua from Oct 2005-May 2006 were combined with data from Concord. This period does not capture storm events during summer and early fall, which is the period of greatest frequency of fast, intense storms. A discussion should be included regarding how the Concord data were verified for the period Oct 2005-May2006. Also, precipitation data sets for modeling are typically chosen relative to a wet, dry, or intermediate year. A discussion relative to this should be included.

Response: As stated in the report, the Concord station was the closest station with a continuous period of record, which is why it was chosen for modeling simulation runs during this period. The Nashua stations did not have any significant periods of continuous precipitation data available. Between October 2005 and May 2006, Pennichuck used data loggers to collect streamflow information for nine tributaries in the watershed. This data was valuable to correlate and calibrate the water budget with precipitation events. Since data from a closer station in Nashua was available for this period, it was used to correlate precipitation events with observed streamflow patterns, providing the most accurate calibration of the water budget, using information within or in close proximity to the watershed. Once calibrated, the water budget could then be determined for any precipitation event and the Concord data was used for this purpose since it included the most comprehensive data set for the period of study in proximity to the watershed.

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Regarding modeling for wet, dry and intermediate years, this is typically performed to evaluate water supply capacity under typical and extreme conditions. Since the focus of this study is on water quality improvements, not the yield of the water supply, the 10-year average inflows and pollutant loadings were determined to be appropriate for this study. Calculation of average annual phosphorus loadings into the pond is consistent with other TMDLs for phosphorus. An evaluation of pollutant loadings during dry and wet years will not change the recommendations of the study, which focus on addressing non-point sources of pollution.

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Page 2-5: Average annual loadings were the focus of the study. High pollutant loads can occur during snowmelt in late winter early spring, and such pollutant loads can contribute to summer season water quality conditions, particularly

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nutrients. Snowmelt not considered important in the study. Also, high pollutant loads can occur during summer and can contribute to a significant portion of the average annual load. If verified summer data are not available, how are the summer pollutant loads accounted for?

Response: A pragmatic approach was taken to estimate and address pollutant loadings in the watershed. Nutrient budgets and loading rates in lakes and ponds are determined on a yearly basis because lakes and ponds tend to accumulate nutrients as well as algal and macrophyte biomass over long time periods compared to rivers, which constantly flush components downstream. CEI agrees that the most sensitive time of year in most lakes and ponds occurs during summer, when frequency and occurrence of nuisance algal blooms are greatest. It would take a substantial effort to determine seasonal variations in loadings and pond response to these loadings, without adding a significant value to the study. The targeted reduction in annual phosphorus loadings will address seasonal variation. For example, control of stormwater runoff, which is the primary culprit for phosphorus loadings in the watershed, will be in place throughout the year, addressing loadings during all seasons.

Page 1-4(?): Figure 1-1 shows BMPs during summer months. Just curious how those BMPs look in the fall or spring (i.e., whether they "look" effective).

Response: Assuming you are referring to the vegetated BMPs, the vegetation does die back in the fall and the BMPs do not "look" as effective. However, a good BMP design, like those shown, do not rely solely on the vegetation for treatment. For example, wet detention uses a permanent pool to remove sediments, while bioretention uses a soil filter media to remove pollutants from stormwater. Overall, the BMPs look really good in comparison to other types of BMPs, and although we do not have seasonal sampling data for the BMPs in the watershed, the UNH Stormwater Center is in the process of collecting year round pollutant removal efficiencies for several BMPs.

Page 2-10: Figure 2-8 is a water budget pie chart for average annual budget for entire watershed. A water budget for each subwatershed should be included.

Response: A table summarizing the water budget for each subwatershed has been added on page 2-10 and is provided below:

"Average annual water budgets by subwatershed are included in Table 2-5."

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Table 2-5. Water Budget by Subwatershed				
Subwatershed	Runoff	Evapotranspiration	Evaporation	Groundwater Flow
1	25%	20%	8%	47%
2	30%	18%	9%	43%
3	33%	17%	10%	41%
4	52%	9%	12%	27%
5	14%	79%	7%	0%
6	26%	17%	10%	47%
7	32%	55%	13%	0%
8	26%	18%	10%	46%
9	26%	18%	10%	46%
10	8%	35%	7%	50%
11	8%	36%	7%	48%
12	5%	40%	6%	49%
13	1%	40%	6%	52%
14	2%	60%	7%	31%
15	1%	32%	6%	60%
16	4%	25%	8%	62%
17	17%	23%	8%	52%
18	21%	21%	9%	49%
19	4%	26%	7%	63%
20	14%	21%	9%	55%
21	6%	19%	10%	65%
22	1%	39%	6%	53%
23	1%	38%	7%	54%
24	2%	34%	7%	57%

Page 2-15: In-pond sampling is described. The average concentration of 38 ug P/L was noted in for Harris Pond (Table 2-7) and is the starting point for reductions. However, 30 ug P/L is the target for reductions (based on text that states 20-30 ug P/L will not likely cause eutrophication or algae blooms. This implies that waterbodies over 30 ug P/L can experience algae blooms. Interestingly, algae blooms were not noted in the report.

Response: A discussion of the impairment, excess algal growth, and its relationship to phosphorus and algae blooms was added to the introduction of the report and to Section 2.2 as shown below.

Introduction: "This report describes the results and evaluation of the Pennichuck Brook Watershed to develop a Watershed Restoration Program to address excess algal growth and cyanobacteria in Harris Pond. Harris Pond is currently listed on the 2006

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305(b)/303(d) Surface Water Quality Assessment for cyanobacteria. Cyanobacteria or "blue-green" algae blooms are caused by excessive nutrient loadings into the ponds, particularly phosphorus, which is the limiting nutrient in fresh water systems. This plan focuses on implementation actions to reduce phosphorus loadings into Harris Pond. A cyanobacteria bloom occurred in the pond as recently as September 2007."

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Section 2.2: *"Two pollutants, total phosphorus (TP) and total suspended solids (TSS) were modeled within the Pennichuck watershed using the SWMM buildup and washoff functions. Total phosphorus was selected as a key pollutant since the impairment in Harris Pond is 'excess algal growth', which is a function of excess nutrient loadings to the ponds. Since phosphorus is the limiting nutrient for algal growth in fresh water systems, often leading to eutrophication and algal blooms, it was selected as the primary pollutant of concern and the basis for setting and implementing water quality goals."*

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Page 3-1: In the "Water Quality Surrogates and Indicators" section, the text notes that in general, 20-30 ug/L will not likely cause eutrophication or algae blooms, although this can vary among water bodies. This is the primary rationale for selecting 30 ug P/L as the target phosphorus concentration described on page 3-2 ("Desired Water Quality"). It seems more apparent that the goal of 30 ug/L was selected based on its consistency with the typical P concentrations of 30-50 ug/L in the Northeast. It is important to note 30-50 ug P/L shown in Figure 3-1 is typical of lakes in the greater Boston area, which may be one of the most densely developed regions in New England. So, the desired goal of 30 ug/L may be artificial, not necessarily working to achieve a more "natural" background level, but merely fitting into a typical developed region. This rationale, therefore, seems weak. In other words, the text provides justification for what is reasonable and attainable, but not necessarily relative to resource objectives, such as lower cost to treat water as potable, reduction of number of algal blooms, etc. These goals rather than a number should be identified, selected, and discussed.

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Response: Based on our experience with watersheds in the Northeast, 30 ug/L is an aggressive goal. Factors include the shallow depth of the ponds, rapid flow of the brook through them, and the high density of development in Amherst, Merrimack and Nashua. In other words, the resource is more like an urban river than a natural, deep pond. Either way, it is not reasonable to expect that the watershed will be able to return to the predevelopment conditions of "natural" that likely occurred in the 1950s.

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Goals could be set for reducing algal blooms, but there have only been two that required treatment on record, 2005 and 2007. Similarly, lower costs to treat the water is not a well-established correlation except for unfiltered systems going to filtration and there the cost is in the tens of millions. CEI knows of no way to correlate these. For Pennichuck, reductions in chemical use might be calculable, but would likely not justify the expenditures Pennichuck has been making for studies, data collection, watershed management, and for the proposed 10-year Capital Improvement Plan. Instead, Pennichuck is doing the work because they are a good watershed steward and know that a multi-barrier approach is the best approach to overall water supply and watershed management. The watershed program is a part of the treatment process, and when looked at in this light, provides a huge cost-benefit in terms of prevented algal blooms, prevented spills and accidents, education of the public, land use controls and specific stormwater practices that control large areas of key subwatersheds.

A second goal of the watershed management program is to preserve base summer flows in order to minimize use of the Merrimack River during the summer. Failure to implement an active watershed management program will result in poor water quality, loss of in pond storage due to a build up of sedimentation as well as increased rated of eutrophication and will result in lower summer flows through the ponds resulting in the need to pump water from the Merrimack.

Page 3-4, Figure 3-1: It is unclear what is actually being depicted by the figure. Average concentrations? If so, what are those averages based on? Figure 3-1 is a primary reference used for rationalizing the target phosphorus concentration of 30 ug P/L, and the average concentrations shown in Table 2-7 are close to that shown in Figure 3-1. However, it is important to note that the actual concentrations in Table 2-7 are extremely variable, above and below the 30-50 ug/L range shown in Figure 3-1. For example, in Holts Pond, only 5 of 17 samples (~29%) were in the range shown in Figure 3-1. In Bowers Pond, only 8 of 42 (~19%) were in the range shown in Figure 3-1. In Harris Pond, only 8 of 32 (~25%) were in the range shown in Figure 3-1. **In fact, for Harris Pond (the target measurement point), nearly 60% of the samples were less than 30 ug/L. So, a more conservative, yet appropriate, target would be something less than 30 ug P/L.** Of the 19 samples that had concentrations less than 30 ug P/L, the average concentration was 14 ug P/L, nearly twice as low the proposed target.

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Response: It is important to remember that this is a 10 year CIP. Based on how the watershed responds to the improvements, and how long they take to implement, then new goals could be set after implementation. Setting a goal of 14 ug/L would not be reasonable in this urban area.

Further, the phosphorus loadings to the pond were based on an average concentration in the pond as shown in Table 2-7, which considered all of the in-pond data, high and low. Thus, the target in-pond concentration would also be based on an average of all data and measures to achieve this target would be expected to result in lower high and low in-pond concentrations. Although many of the sampling rounds could meet a lower target, it is the overall average that is used in the modeling and loading analysis. The high concentrations observed in the pond, although fewer, play a big part in the average concentration and cannot be ignored when selecting a target concentration, when they play such a big part in establishing the overall loads. We believe the approach taken and target established make the best use of the data for the pond.

Page 3-4 states that TSS is likely due to stream bank erosion, rather than stormwater pollutant loads. However, no discussion is made relative to changes in the hydrology (peak flows and volumes) due to stormwater runoff and how those changes contribute to stream bank erosion. Changes to hydrology and subsequently TSS loads are an indirect contribution of stormwater runoff. So, mitigation may not be needed for settling, but for flow attenuation before discharge to streams.

Response: CEI agrees that changes to hydrology and subsequently TSS loads are an indirect contribution of stormwater runoff and that flow attenuation before discharge to streams is an important component. Recommendation #5 discusses the adoption of new state stormwater standards for new developments. These new state standards incorporate requirements for channel protection that are geared towards the flow attenuation necessary to prevent channel erosion associated with stormwater runoff. Some additional discussion on the benefits of flow attenuation to prevent channel erosion have been incorporated into this recommendation, with some additional language on page 3-4 as shown below:

Page 3-4: "Further, the recommendations in Section 6.0, particularly Recommendation 5 Encourage Local Adoption of State Stormwater Standards and Recommendation 8 Evaluate Sediment Accumulations, will address control of streambank erosion through better control of peak flow attenuation that causes streambank erosion and other measures as deemed necessary."

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Recommendation #8: "Adopt state stormwater standards locally as discussed under Recommendation 5. These new state standards incorporate requirements for channel protection that are geared towards the flow attenuation necessary to prevent channel erosion associated with stormwater runoff and will help prevent a major source of streambank erosion."

Paul Susca Comments

If this is to serve as a model, I'd suggest including two things, one being a different representation of data that's already in the report, and one being something new:

1) A graph showing the marginal cost per pound of reducing P loading. Horizontal axis would be P removal, starting with the most cost-effective measures (local stormwater standards, then public education, etc.), and vertical axis would be cumulative P removal. And you could include a horizontal line showing the P removal goal. You could also label points on the curve showing cumulative cost. The data are all in Table 5-1 - some number crunching required.

2) The new data would be expected impact on Pennichuck's treatment costs under various P loading scenarios. For example, a 1997 study by the Department of Agricultural Economics at Texas A&M University, which looked at 12 geographically representative water suppliers over three years, found that treatment costs increased one percent for every four percent increase in raw water turbidity. I don't know of any other data of this nature.

Response: 1) The data in Table 5-1 is focused on the capital expenditures associated with each recommendation and does not include the long-term operational costs associated with each. Therefore, some measures appear to be more cost-effective than they may actually be in practice due to the longer term costs involved. For example, the purchase of a street sweeper reveals a relatively low cost compared with the detention basin retrofits. However, annual use of the sweeper will require staff to operate the equipment, as well as the cost of gas and maintenance. For this reason, such a figure can be misleading in terms of actual costs.

2) It is extremely difficult to tie phosphorus concentrations to treatment costs in the pond. Although excess phosphorus loadings lead to algae blooms, it is only one factor in the type and severity of the bloom. Temperatures, base flows, stormwater flows and precipitation can all impact blooms. The blue-green algae

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blooms are the most difficult and costly to treat. Pennichuck experienced blue-green algae blooms in August 2002 and September 2007. Due to the many factors involved, a linear relationship between phosphorus levels and treatment costs can not be drawn.

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Barbara McMillan Comments

On page 5-3, Part 1 of the social marketing plan and in 1-B, 1-C, and 1-D, throw in a little language about research that gives these methods their clout.

Response: Information on research that gives these methods their clout has been added to this recommendation, as shown below:

"Conventional marketing and education efforts that rely on media and advertising typically have little to no effect on overall behaviors as shown in a number of studies[1]. For example:

- *High school students who participated in a 6-day workshop focusing on creating awareness of environmental issues were found in a follow-up to be no more likely afterward to engage in pro-environmental actions.*
- *Households provided with information about energy conservation did not reduce energy use.*
- *Household volunteering to participate in a 10-week study of water use received a state-of-the-art handbook on water efficiency. Despite great attention paid to the preparation of the handbook, it was found to have no impact upon consumption.*
- *Two large surveys found that environmental information, knowledge and awareness were poorly associated with environmental behavior.*
- *In one study, individuals who have strong energy conservation attitudes were found no more likely to conserve energy.*

As shown above, increasing knowledge and changing attitudes have little impact on actual behavior change. To address these findings, an approach referred to as community based social marketing was developed, which focuses on changing people's behaviors, rather than just distributing information. The approach involves surveying current behaviors and identifying barriers that keep people from performing certain actions. The survey results are used to develop an action plan to change the ratio of benefits and barriers so that the target behavior(s) becomes more attractive. Implementation elements often revolve around commitments, reminders and prompts, establishing a norm,

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creating a vivid message, developing goals and feedback and providing incentives.

The community based approach has been very effective in promoting sustainable behavior.[1] For example:

- *Home energy auditors trained to use behavior change tools for the largest utility in the United States, Pacific Gas and Electric, persuaded three to four times as many households to weatherize their dwellings.*
- *When used to promote recycling, community based social marketing techniques have resulted in dramatic increases in recycling."*

Although there seem to be some milestones, (g in the a through i), outlined in the budget and timeline, I think that these could be in more detail (i.e. for 1C Door Hangars: Short Term: Identify possible messages for hangars from Amherst pilot program. Mid term: Identify and meet with partners, design additional educational accompanying material or programs, and distribute door hangars. Long Term: Evaluate and make appropriate adjustments).

Response: More detailed milestones have been added to the recommendations in Figure 5-1 (attached).

This is probably more of a format and organizational issue than content but for the user or implementer of this plan, there also appears to be cross connections that are not really identified to the reader, i.e., *Pg 5-4, 1-E Coordinate with Phase II Coalition* and there is no mention of the recommendation on *Pg. 5-7 Encourage the Adoption of New State Stormwater Standards for new Developments* second paragraph "This would satisfy each of the Phase II communities' need to update their regulations as mandated under Phase II federal rules." This makes it really hard to follow, implement and evaluate, other than the implementer having to go through and pick out what overlaps before they do anything. I think it is based on too many assumptions to expect that to be done. A suggestion would be to add an: **Associated Recommendations:** 5-2 #5 and 5-2 #10 (and there may be others for the Phase II one).

Response: The format has been revised with an "Associated Recommendations" piece added to each recommendation.

Rather than using a narrative approach for the Recommendations chapter, try breaking it out with an action plan for each recommendations with a clear

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progression for implementation that someone new to the process could seize and run with. For example, consider a format with specific headings and directives as follows:

Recommendation:

Objectives:

Milestones:

Funding Source:

Partners:

Actions:

Budgeted Costs:

Associated Recommendations:

Measurement:

Evaluation:

Response: Section 5 has been reorganized per your recommendations and a new milestone schedule has been developed as Figure 5-1. The 'Evaluation' element that you mentioned above was not included for each recommendation. Instead, the success indicators under 5.3 are used to describe how the overall plan will be evaluated in terms of its effectiveness. It is difficult to measure the success, on water quality, of each individual recommendation. CEI has incorporated the measurement of success of each individual recommendation into the 'Measurement' element,.

Steve Landry Comments

This draft plan is coming close to satisfying the a-i key elements that EPA and DES require for watershed management plans. The only element that is lacking at this point is "g" as mentioned by Barbara in her comments above. I would recommend that each section under 5.2 (Recommendations) be reviewed and have milestones established.

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Response: Figure 5-1 has been revised to include milestones for each recommendation (see attached).

A more structured or outline approach to presenting recommendations may be beneficial in securing that implementation moves forward in a logical fashion. The narrative exists within the draft plan to create these "workplans" as suggested by Barbara in her comments above. This structured approach will allow for the inevitable personnel or consulting team changes that may occur over the next ten years within the watershed. The final plan document should be structured in such a way that any organization, municipality, or interest group could pick it up, review the recommended action plans quickly, and be able to see if they can take the lead on them. Having the full narrative text approach may dissuade some people from digging in to the plan. Developing the recommendation workplans will also save time down the road and eliminate the need to translate the text into a time-bound, milestone oriented format.

Response: CEI has restructured the recommendations per Barbara's comments.

On page 5-3, Section 1C – Is it "Door Hangars" or "Door Hangers"?

Response: The correct term is "Door Hangers". This has been corrected in the text of the report.

Eric Williams Comments

We should also ask PWW to include in the opening section of the document what the impairment is that the plan addresses, i.e. cyanobacteria in Harris Pond.

Response: A discussion of the impairment has been added to the first paragraph of the introduction, as shown below.

"This report describes the results and evaluation of the Pennichuck Brook Watershed to develop a Watershed Restoration Program to address excess algal growth and cyanobacteria in Harris Pond. Harris Pond is currently listed on the 2006 305(b)/303(d) Surface Water Quality Assessment for cyanobacteria. Cyanobacteria or "blue-green" algae blooms are caused by excessive nutrient loadings into the ponds, particularly phosphorus, which is the limiting nutrient in fresh water systems. This plan focuses on implementation actions to reduce phosphorus loadings into Harris Pond. A cyanobacteria bloom occurred in the pond as recently as September 2007."

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Please contact me if you have any questions or require any additional information at 1-603-424-8444 ext. 308.

Sincerely,

COMPREHENSIVE ENVIRONMENTAL INC

Rebecca Balke

Rebecca Balke, P.E.
Principal, Project Manager

Attachments/Enclosures –

- 5 copies of the Final Watershed Restoration Plan
- 1 disk containing an electronic copy of the Final Watershed Restoration Plan

cc: Donald Ware, President; Pennichuck Water Works

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